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JOURNAL

OF THE

AMERICAN WELDING SOCIETY

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AMERICAN WELDING SOCIETY

ESTABLISHED 1919

JOURNAL

VOL. 1 JUNE, 1922 NO. 6

KEEPING DOWN EXPENSE OF PUBLICATION OF JOURNAL

Our members will be interested to know how the reduction of the cost of publication of our Journal is made possible. One of the chief items of expense in connection with the printing of technical papers is that of making cuts of illustrations. With the limited funds that are available for our Journal, it would be practically impossible to publish as many valuable papers as have appeared in each issue, containing numerous illustrations, were it not for the help rendered by our good friends. In several instances, the cost of these cuts has been paid by the companies with which the authors are connected. For such assistance our thanks are due to the Acetylene Welding Journal, Davis-Bournonville Company, Electric Arc Cutting and Welding Co., American Rolling Mill Co., National Tube Company, Air Reduction Company, International Nickel Co. and Page Steel & Wire Co.

A 100 PER CENT RAILROAD

Through the untiring efforts of Mr. T. F. Barton, Master Mechanic of the Delaware, Lackawanna and Western Railroad, (also Chairman of the New York Section of the American Welding Society), the American Welding Society is able to report with pleasure that we have one railroad whose welders are all members of the Society. An idea of Mr. Barton's activities in this direction can be gained from the fact that he secured 21 new members during the past month.

RESEARCH ACTIVITIES

WELDED RAIL JOINT COMMITTEE ISSUES FIRST PROGRESS REPORT

Welding is being very widely used in making street railway joints. More or less trouble has been experienced in all types of welded joints through breakage. Little or no scientific data exist as to the correct procedure to be followed in making welds by the various processes. Replies received to a questionnaire sent out by the Committee on Welded Rail Joints show a wide difference of procedure by the different railway companies in making these joints.

The larger companies are spending many thousands of dollars per year on such joints. That there is a real need for an investigation of this sort is evidenced by the attendance at the first meeting held in New York at which 26 representatives from railway companies (as far west as Minneapolis), engineers from manufacturing interests and others were present. Since the organization of the Committee there have been several meetings of the small Executive Committee appointed by the Bureau. This small Committee framed a questionnaire on the four types of joints, namely cast iron, electric resistance, electric seam and thermit, which was distributed to the members

of the main committee. Answers to these questionnaires were all correlated, condensed and a progress report of 73 pages was printed and distributed to the members of the Committee. Typical problems needing investigation as brought out from replies received from the inquiry schedules is also included in the report.

At this meeting the Committee approved the Bureau's appointment of Dr. G. K. Burgess, as Chairman, Mr. E. M. T. Ryder, as Vice Chairman and Mr. W. Spraragen, as Secretary. The other members of the Executive Committee are: Professor C. A. Adams, R. C. Cram, H. M. Steward, W. W. Wysor, E. J. McIlraith and G. L. Wilson.

The types of joints to be tested as typical of present day practice were introduced by speakers designated in advance by the Executive Committee and also participated in by those present. The discussion was particularly aimed at bringing out those problems needing further investigation.

In order to have a uniform type of rail and section it was agreed that all test joints should be made on A. E. R. E. A. Standard 7-in. girder rail, Class B. Three test specimens are to be taken in each case. In the case of patented joints, manufacturers will be requested to furnish three joints for each test in addition to the test joints to be furnished by the users. The following tests will be made on full size specimens, welded as nearly as practicable under service conditions: (a) tensile test, (b) drop tests, (c) cross bending test. All tests are to be made to destruction. The Committee recognizes that it is desirable to have constructed a rotary service test machine of some 80 feet in diameter to simulate wear tests. If it is found possible to finance the construction and operation of such a machine the Committee will be enabled to make tests in one month equivalent to five years of actual service. It is estimated that it will cost some $14,000 to build and operate this machine for the first year. Other types of wear tests are under consideration as well as laboratory tests on small specimens.

While no difficulty is anticipated in securing materials from manufacturers, test specimens from railway companies and testing by the Bureau of Standards and University Laboratories, cash contributions are also necessary. The budget as drawn up by the Executive Committee amounts to $15,000 for the first year aside from materials and services noted above. Efforts are being made to secure the necessary financial support from the interested railway companies as well as manufacturers.

WELDING WIRE SPECIFICATIONS

The Welding Wire Specifications Committee held a meeting in New York on April 26. At this meeting it was unanimously agreed that the folio covering coated electrodes should be revised as follows:

Page 10, Chemical Composition, reading, "The chemical composition shall be within the following limits for the uses specified," changed to read, "The following chemical compositions have been successfully used."

A foot note was also added to the bulletin covering distinguishing marks for welding material as follows:

"For the purpose of identifying welding material of different compositions such as iron, steel, cast iron, etc., it is suggested that the user designate a color for each metal, this color to be applied to the bundle or to the ends of the wire or rods when the material is placed in store room."

Tests are under consideration by the Committee to determine the qualities of good welding wire other than chemical composition. These tests are substantially those proposed by the Committee on Specifications for Steel to be Welded and are:

First—Melting the wire by the oxy-acetylene flame to determine flowing qualities and condition of the metal.

Second—Melting the wire by electric current.

Third — Baking on a vitreous enamel by heating electrically.

Fourth — Testing welds produced by extremely good, intermediate and poor wires as indicated by melting test. The tests on welded specimens

are to consist of tensile, bend and microscopic tests as laid down by the Committee on Methods of Testing Welds in Bulletin No. 1. In this way it may be possible to clarify present specifications.

A Committee was appointed to determine standard methods for distinguishing welding material of different compositions. Considèration is also being given for drawing up specifications of proper welding wire to be used in welding manganese, nickel and alloy steel.

OPINIONS VERSUS RESEARCH

One of the major problems of the A. S. M. E. Boiler Code Committee has been the formulation of rules for the construction of unfired pressure vessels. This undertaking came about as the result of an insistent demand from various states and municipalities for a code which would form the basis of rules governing the construction of unfired pressure vessels of various sorts. The crucial point on which a code of this sort really depends is welding. Indeed, the extensive ramifications of the kind of unfired pressure vessels which are built and the magnitude of the industries involved are such that the A. S. M. E. Boiler Code Committee has felt it necessary to proceed with extreme caution.

In March, 1920, the Council of the A. S. M. E. requested the American Welding Society to appoint a Committee to co-operate with the Boiler Code Committee of the A. S. M. E. in the preparation of that part of the code which deals with fusion welding. A tentative code based upon the opinions and experience of experts was drawn up by this Committee. With this assistance the Boiler Code Committee prepared a code covering the points which seemed to them pretty well settled, together with an appendix containing questions covering matters on which considerable differences of opinion prevailed. A public hearing was held on Dec. 5, 1921, at which this tentative code was reviewed. As is usual on such occasions a great variety of opinions were expressed and many other broad statements made by those who have had experience in this field. As a matter of fact, the real amount of authentic unbiased experimental evidence contributed was small as compared with the need and importance of the problem.

To supplement the public hearing on Dec. 5, a symposium on welding was arranged at Atlanta on May 11, 1922, under the joint auspices of the A. S. M. E. Boiler Code Committee and the American Welding Society. Four papers directly reflecting upon the subject were selected for presentation. These papers were "Steel for Forge Welding," by F. N. Speller, which dealt with the method of manufacture, composition, fluxing quality, susceptibility of metal to heat, welding temperature and the average results of a large number of tests made on forge welds of hammer welded pipe, as compared with the original material; "Tests of Welded Cylinders," by E. A. Fessenden and L. J. Bradford, which dealt with the tests of four types of construction used in making cylinders for handling anhydrous ammonia; "Some Principles of the Construction of Unfired Pressure Vessels," by S. W. Miller, dealing with general considerations governing the applicability of fusion welding to pressure vessel construction, welding efficiency, factors effecting welding efficiency, best composition of base weld metal, welding wire composition, type of joint, proper welding conditions, welding material, the welded versus riveted tank, and tests on welded vessels; and "Strength of Electrically Welded Pressure Containers," by R. J. Roark, which describes the pressure tests made on electrically welded, gas welded and riveted pressure containers. The session was well attended and considerable discussion elicited. As in the other hearing, differences of opinion prevailed among the experts present. One of the subjects on which a wide difference of opinion prevailed was that of the proper composition and quality of the plates to be used in the construction of pressure vessels that are to be welded. No definite conclusions were reached.

These four papers bring out very

strongly the need of further investigation on this subject. If we are to depend solely upon the conflicting opinions of the experts, further progress must necessarily be slow.

Realizing the need for more complete information, based upon sound scientific investigation, the American Bureau of Welding held a meeting for the purpose of organizing the manufacturers to deal co-operatively with the situation at hand. The need for this co-operation and benefits to be derived was brought out very strongly by Director C. A. Adams and S. W. Miller. The viewpoint of the Boiler Code Committee of the A. S. M. E. and insurance people was brought out by Dr. D. S. Jacobus and S. F. Jeter, respectively. It was the consensus of opinion of those present that an organization of this sort should be formed with the least possible delay. However, since that time only a small fraction of the tank manufacturers signified their willingness to participate in this movement. The limited number of co-operators has made it necessary for the Bureau to propose a much more simple program of research than that originally contemplated. The plan proposed is briefly as follows:

Each co-operating manufacturer will weld three tanks according to his standard practice, of a size that will be determined by an appropriate committee. These tanks will be shipped to some central testing laboratory such as the Bureau of Standards, or a university laboratory and tested to destruction. A report will then be published which will include:

1. A distinguishing letter or symbol for the product of each manufacturer (name of manufacturer will not be published).

2. Results of destructive tests of tanks.

3. Results of tests of coupons taken from tanks.

4. Complete information concerning the construction and details of welding (to be furnished by the manufacturer).

If enough manufacturers signify their willingness to co-operate in this simple program, the Bureau will appoint a Committee of experts to draw up (a) standard tests to be made on the tanks which will yield the maximum information possible, (b) data sheet to be filled in by the manufacturers as to the methods of welding and construction used.

Such a report will be complete in itself. It may or may not be possible to draw up a code from the results obtained, but they will be a starting point. Moreover, the results may indicate which of certain practices now employed by different manufacturers are the best. It will also enable each manufacturer to know the comparative value of the products involved.

As previously pointed out, the fact of the matter is that we have gone as far as we can with the experience and evidence at hand and that further progress, if it is not to be accompanied by unnecessary delay, must depend on research. It is interesting to note that one of the major problems involved, namely, that of the quality of material to be welded, is already receiving the attention of the American Bureau of Welding through an appropriate committee and tests are now being made to determine the reliability of certain methods that have been proposed to distinguish between good and bad qualities of steel for welding purposes.

SECTION NEWS

CHICAGO

The May meeting of the Chicago Section was held in the rooms of the Western Society of Engineers, Friday evening, May 5th.

The meeting was devoted to an illustrated paper by Mr. Fred J. Mauerer of the Chicago office of the Airco-Davis-Bournonville Company, on the subject of Efficiency of Machine Cutting. Mr. Mauerer, who has been identified with the oxy-acetylene industry since its very outset in this country, and who has had wide experience in the field of automatic cutting and welding, was enabled to present from his work, especially in the steel mill districts, much interesting data on this subject.

Sixty welding enthusiasts were on hand to hear this paper and to participate in the valuable discussion which followed.

It has been decided to dispense with further meetings of the Chicago Section during the summer months.

PHILADELPHIA

An interesting meeting of the Philadelphia Section was held on the afternoon of May 15th. Mr. M. G. Lloyd, Chief of Safety Section, Department of Commerce, Bureau of Standards, gave an exceptionally good talk on "Welding Lenses." Mr. Lloyd described in an entirely understandable way the lenses best suited to offset the dangerous ultra violet rays. He mentioned the following Bureau of Standards pamphlets dealing with the protection of the head and eyes of the industrial workers:

Technologic Paper No. 93, Glasses for Protecting Eyes from Injurious Radiations, by W. W. Coblentz and W. B. Emerson.

Technologic Paper No. 119, The Ultra Violet and Visible Transmission of Eye Protective Glasses by K. S. Gibson and H. J. McNicholas.

Technologic Paper No. 148, The Ultra Violet and Visible Transmission of Various Colored Glasses, by Gibson, Tyndall and McNicholas.

Scientific Paper No. 325, Spectro Radiometric Investigation of the Transmission of Various Substances, by Coblentz, Emerson and Long.

Handbook No. 2, "National Safety Code for the Protection of the Head and Eyes of Industrial Workers."

These pamphlets contain many charts showing what the various color lenses accomplish and what they fail to accomplish in the way of protection.

PITTSBURGH

The May meeting of the Pittsburgh section which was held on May 26th was devoted to a paper, "Some Limitations of Metallic Electrode Welding," by Mr. J. F. Lincoln of the Lincoln Electric Company. This will probably be the last meeting of this section until fall.

EMPLOYERS, ATTENTION

WE HAVE IN OUR FILES THE RECORDS OF MEMBERS WHO HAVE HAD FROM ONE TO FIFTEEN YEARS' EXPERIENCE IN THE WELDING FIELD. IF YOU NEED ANY WELDING TALENT, KINDLY LET US KNOW. THIS SERVICE IS FREE.

V-4—Can use four good arc welders if they can report at once. Steady work. All piece work, 6c per linear foot, water tight tank.

MANUFACTURE AND USE OF COMMERCIALLY PURE IRON IN GAS AND ELECTRIC WELDING

C. A. McCune†

Early Uses and Manufacture in This Country

In the first commercial application of welding, the lowest carbon welding metal was mostly desired as the metal was found to flow evenly and smoothly and welds made with it contained consistently less imperfections than were obtained with higher carbon metals on account of the absence of impurities such as were naturally present in metals of higher carbon content.

In the beginning, Norway iron was principally used as a welding material, but on account of the enormous increase in the application of the welding process in the United States and the shortage of the pure Norway product, it was necessary to produce in this country a similar metal, purer if possible, made on a more modern basis. Realizing that purity and uniformity were the principal factors in the Norway iron, commercially pure iron was later developed for welding purposes.

An interesting history of how the manufacture of commercially pure iron in the open hearth furnace came about was presented in a paper read at a meeting of the American Iron & Steel Institute at New York, May 27, 1921,* of which the following is an extract:

"The first announcement before a scientific and technical body that the manufacture of commercially pure iron had been successfully accomplished in the open hearth furnace was in a paper which was read at a meeting of the American Society for Testing Materials in 1911.**"

"It cannot be questioned that there has always existed a demand for the purest obtainable iron. This demand has held steadfastly in the face of rapidly developing steel producing processes. The steady importation of Norway and Swedish irons throughout our entire metallurgical history up to the outbreak of the war in 1914 is sufficiently indicative of this fact. These foreign irons, however, that had to be laboriously worked down by a charcoal or puddling process were not suited to the large-scale tonnage operations which are made imperative by American conditions of labor and industry. It is natural, therefore, that our metallurgists should have been led to the consideration of adapting the open-hearth steel furnace to the manufacture of iron of at least an equal degree of purity as those types which were imported from overseas."

"Before progress along this line could be made, however, grave manufacturing risks had to be faced without much fore knowledge

*The Development of Commercially Pure Iron in the Basic Open-Hearth Furnace, W. J. Beck, Director of Research, The American Rolling Mill Co., Middletown, Ohio.

** The Manufacture of Pure Irons in Open-Hearth Furnaces, A. S. Cushman, Proceedings, American Society for Testing Materials, Vol. XI, 1911.

†Sales Engineer, Page Steel & Wire Co.

as to whether a successful, workable and salable product could be finally achieved. Every open-hearth man knows what is implied in raising the temperature of a bath two hundred degrees above the normal practice and maintaining this temperature until the carbon and manganese are run down to practically traces."

"The undertaking of pioneer work in this direction was certainly not altogether promising. Ledebur, the great German authority, had clearly stated in his compendious work in iron metallurgy that any such operation with the open-hearth furnace would be in vain if not freighted with disaster. In 1903, a very distinguished American metallurgist, H. H. Campbell, made an attempt at an open-hearth pure iron, and finished with carbon .025, manganese .040. Campbell did not follow up this step, however, and summed up his opinions in the following brief comment: 'These heats were made in a basic open-hearth furnace and their regularity both in chemical and physical character shows that we are dealing with a normal and definite metal and not with an accidental product. They were purposely made with the lowest possible content of manganese and it seems positively certain that the metal must be saturated with oxygen.' It is evident from the foregoing that so eminent an open-hearth man as Campbell thought that in carrying manganese down to .04 the procedure had gone as far as possible and that only an overburned metal was the result."

"Continuous progress in the art was made until finally it was proved possible to reduce the five ordinary impurities of iron (carbon, manganese, sulphur, phosphorus and silicon) to the point at which in the aggregate they did not exceed fourteen-hundredths of one per cent. At the same time special methods had to be studied to attain the maximum degree of degasification and the proper deoxidation."

"Ingot iron made in an open-hearth furnace differs from the older irons in having a typical crystalline structure, a more definite critical temperature range, and more particularly in being essentially free from slag."

"As the experimental work progressed it was found that there were considerable differences in the practice of producing commercially pure iron as compared to steel practice, which materially added to the cost. In the first place, it required several hours longer to make an iron heat than a steel heat, and the final temperature of the metal was 200 degrees Fahrenheit higher than a heat of steel. Another marked difference was also found between the percentage yield of metal as compared with the percentage yield when steel was made. The percentage of metal produced was several per cent lower in the iron heats because the high temperatures and longer time employed in the manufacture of iron oxidized more of the iron, which was lost in the slag."

"In order to emphasize the importance of the selection of raw materials in the manufacture of commercially pure iron, attention is

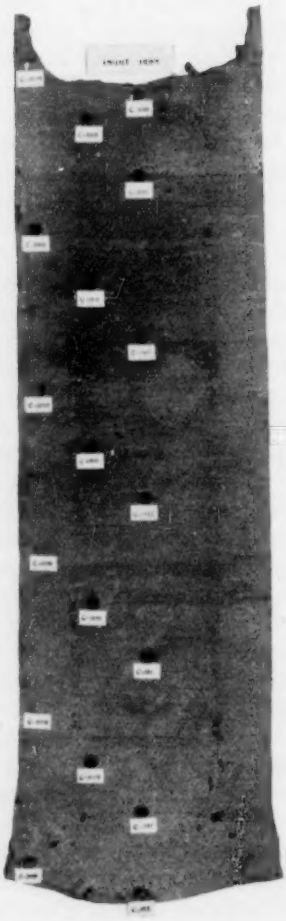

Fig. 1
Ingot of Commercially Pure Iron, showing practical freedom from blow holes, etc. The range in analysis shows Carbon Min. .009. Max. .011. Difference .002

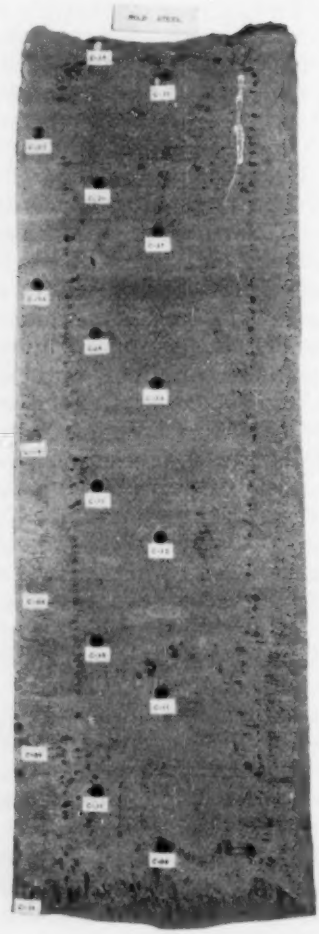

Fig. 2
Split Ingot of Open Hearth Steel. The range in analysis shows Carbon Min. .07. Max. .20. Difference .13.

called to the fact that there are certain elements which if they exist in the raw material are not eliminated in the open-hearth furnace. Among these elements which cannot be eliminated are copper, arsenic, antimony, tin, nickel and cobalt."

"The purity of this product and the careful methods used in its manufacture make it more homogeneous than steel, and it therefore flows uniformly when heated to a melting temperature.

"The average analysis compiled from records covering a period of twelve months shows this iron purity to be 99.865 per cent. This takes into consideration the nine impurities—silicon, sulphur, phos-

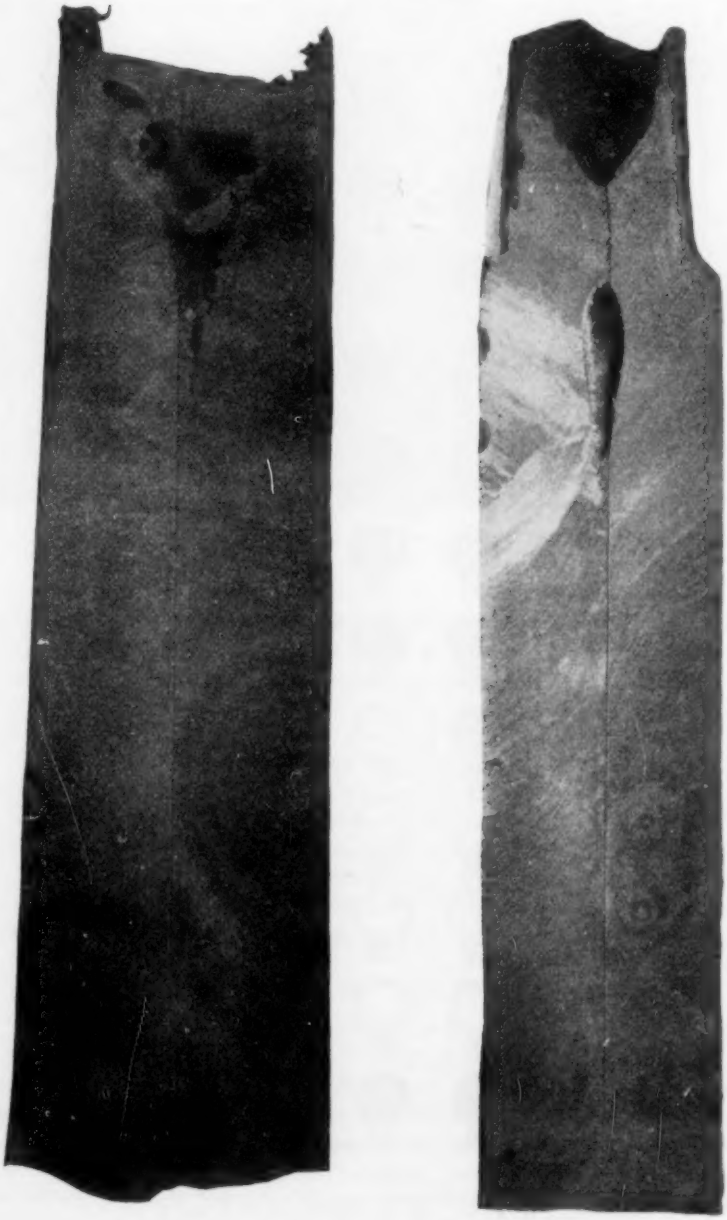

Fig. 3 Fig. 4

Some Ingot Structures.

phorus, carbon, manganese, copper, oxygen, hydrogen and nitrogen."

Top of Ingot

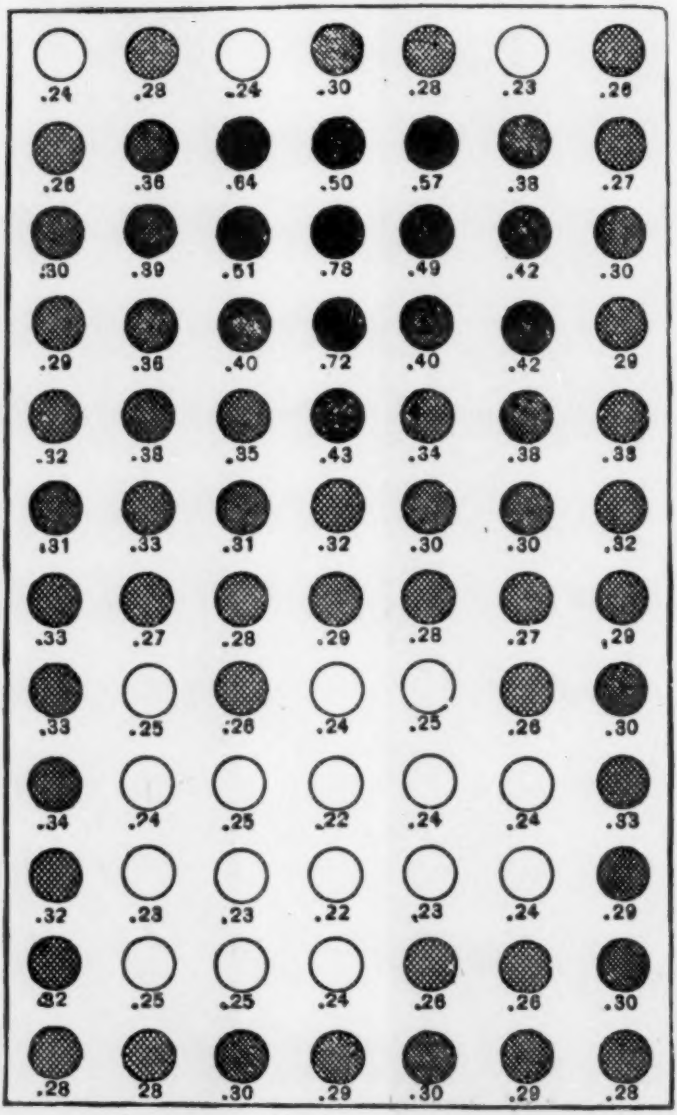

Fig. 5
Showing possible segregation of carbon in a normal .20 carbon steel ingot. (See page 181, 1908 edition) Bradley Stoughton on Iron and Steel.

This history of the development of commercially pure iron clearly shows that in the early days of metallurgy, analysis included determinations of only the elements which were commonly known as the BIG 5; namely, carbon, manganese, phosphorus, sulphur and

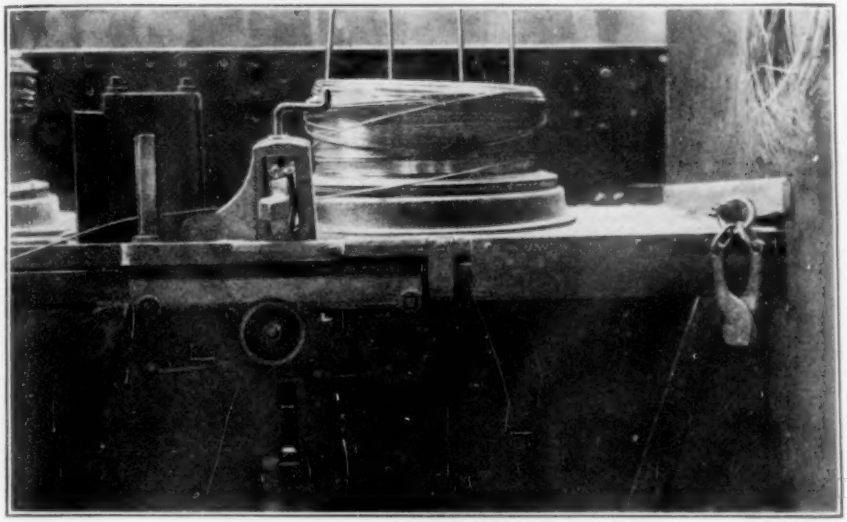

Fig. 6
Wire Drawing Block.

silicon. The aggregate of these was subtracted from 100, and the remainder indicated the percentage of iron. Previously very little attention, if any, was paid to degasification, but it was later found that by the elimination, as far as possible, of such gases as oxygen, hydrogen and nitrogen, there resulted a more sound metal.

No great demand existed for welding material of other than foreign manufacture until it was no longer possible to secure this product in the United States in commercial quantities. It was not until the year 1914 that wire manufacturers of the United States had a real opportunity of proving that they could meet the demand for welding materials and that low carbon iron, particularly, could be produced here superior to any foreign product.

Welding Wires with High Carbon Content

The scarcity of genuine Swedish or Norway iron brought forth a vast number of substitutes of various analyses ranging up to .20 carbon. Very few of the contentions advanced for their use were accompanied by even sound logic let alone scientific data, making it necessary for the consumer to spend time and money experimenting with various grades of welding metal. It remained for the Emergency Fleet Welding Committee to first arrive at some definite specifications and limit of carbon and other elements for the selection of acceptable welding material.

There was less deviation in iron welding material used in oxy-acetylene welding than in the metallic arc process probably due to the fact that little was known of properly treating and processing

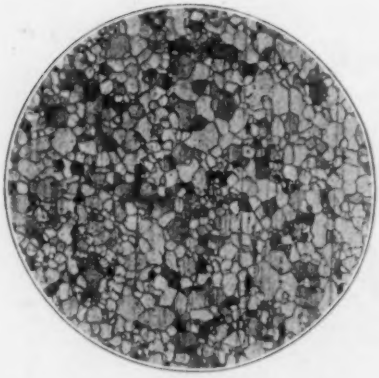

Fig. 7
Typical Grain Structure of Oxy-Acetylene Welding Rods.

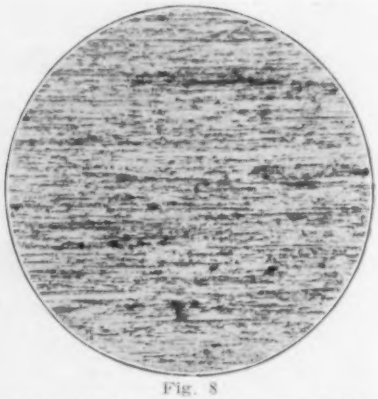

Fig. 8
Typical Grain Structure of Electrodes.

The result of proper drawing and heat treatment of a uniform metal.

iron and low carbon wire for electric welding. As the result of a certain amount of success it was considered by some much simpler to meet the extraordinary welding demands that existed with an ordinary steel wire than devote the considerable time necessary to work out this problem. As our knowledge of welding broadened, and time allowed for experiments, general improvements were naturally expected. Manufacturers engaged in the production of low carbon material fully realize that a low carbon content metal can be produced more uniform in analysis and with a better assurance of the elimination of impurities and gases. Many investigations have shown that an iron ingot is freer from deep seated blow holes and surface blow holes than the ordinary mild steel ingot (see Fig. 1 to 6). These defects in ingots have been found in the resulting wire in approximately direct proportion to the area and moreover may introduce seams and laps and general non-uniformity of structure. It, therefore, does not require any great metallurgical knowledge to realize that a sound ingot will produce a more homogeneous, slagless wire. This may be observed in Fig. 7 which shows the structure of oxy-acetylene wire and in Fig. 8 which shows the structure of electrodes.

Welding Wire of Same Composition as Base Metal

Research has shown conclusively that claims of the advantages of using welding material of a similar analysis as the base or parent metal, particularly when welding mild steel, are not sustained, and the reason for this can be fully understood, when it is considered that welding is re-casting metal. To expect a cast metal of a similar analysis to possess the identical physical characteristics of a rolled and specially treated sheet or plate, is asking more than could possibly be obtained.

Where we have attempted to secure welds with analysis approximately the same as the base mild steel, the welds have been found to be extremely brittle in relation to the base metal.

We have found that with a mild steel welding wire that does perform best a considerable chemical and metallurgical change takes place, and although the welding material may be of a low carbon or mild steel analysis ranging up to .20 carbon, which allows a very wide range, the deposits secured from this variety of welding material will analyze so close in carbon that there would remain no appreciable relation in the carbon content of the deposit secured, to the original welding material except in the case of very low carbon metals not over .06 carbon.

A considerable number of tests made on ½-in. plates of mild steel and commercially pure iron, to determine the analysis of deposits of mild steel wire (.08 to .20 carbon) and commercially pure iron (.02 carbon) by both the electric and oxy-acetylene process, showed an average deposit of .03 carbon, this figure fluctuating with the analysis of the plate.

The loss of the carbon occurs through the heat of the welding process and the presence of oxygen from the air. The carbon in the welding rod is exposed to the oxygen of the air and combines with it forming carbon monoxide or carbon dioxide gas which is very apt to be entrapped in the weld metal forming gas pockets or blowholes. Furthermore, the manganese in the welding rod is readily oxidized by the oxygen of the air, forming manganese oxide which may also become entrapped in the weld in the form of slag, presenting a possible combination of conditions which tend to produce defective welds. Further evidence that gases are recognized detriments is shown by the development of coated electrodes, one duty of the coating being to guard the molten weld metal against contaminations by the oxygen and nitrogen of the air.

When it is realized that in mild steel plates, etc., the carbon ranges from .08 to .25, a difference of 17 points, it would indeed be difficult to obtain a rod of such analysis that would meet the variation in the base metal even if this were a recommended practice, which it is not.

The fact that the original welding metal of mild steel is reduced practically to iron in the weld, and that there is no radical change in iron from the welding metal to the deposit, is evidence that carbon steel welding metals above .06 carbon have no advantages for the welding of mild steel parts.

Gaseous Inclusions

Films of oxide (see Fig. 9 and 10) between the grains or blow holes in the weld are very important factors in producing defective welds, but oxides are not alone or entirely due to the burning out of the carbon, but just as frequently result from the occluded

Fig. 9
Microphotograph showing slag inclusions in an electric weld.

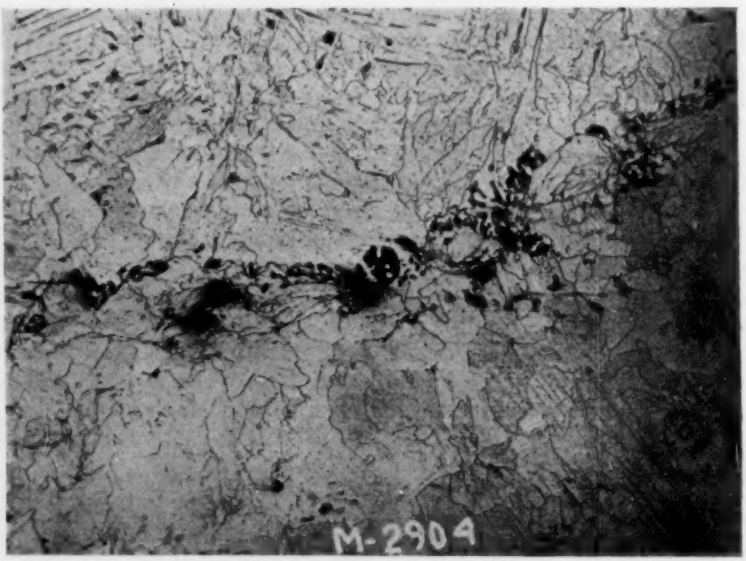

Fig. 10
Microphotograph showing slag inclusions in a gas weld.

Slag Inclusions in Welds Due to the Use of Inferior Welding Wire

Fig. 11
Typical Welds.
Welds such as these are the rule where the fundamentals of welding are observed. Trained operators, reliable equipment, uniform base metal and welding wire.

gases contained in the welding wire or the base metal. The welding heat disturbs and expands the gases present and in endeavoring to liberate themselves the molten metal is ruptured and exposed to the air—making oxidization possible in the channel created. In most

cases this channel is at or near the edge of the "V" where there is usually found a mixture of carbon of the base metal and welding metal, and as this point cools more rapidly than the center of the welds, it is the first to freeze and trap any oxide and gases. The disturbance, however, continues until the mass has cooled throughout. Naturally this all takes place very rapidly and in a very small space, but it may be compared to a heat of steel of the analysis in question where it is possible to observe the freezing of the tops of ingots of 5,000 pounds weight after pouring from the ladle and later, to view the cross-section of the ingot itself. This cross section shows that blowholes are present, which as a general rule is expected and not considered detrimental for the purpose intended as the ingot is later to be re-heated, rolled and otherwise processed, but which is not practical with mild steel welds. Due to the fact that material deposited by the fusion welding processes is similar to a casting, it is essential that the deposit be sound, free from gases and slag inclusions in order that it may most consistently approach the characteristics of the base metal.

Commercially Pure Iron Welding Wire and Plate

It has been proved beyond question by innumerable practical applications, test specimens, etc., that commercially pure iron wire of correct physical properties possesses every essential that could be advanced for a suitable metal for welding mild steel plates, shapes, etc., by either the oxy-acetylene or electric arc process. Furthermore, continued research develops that whereas the efficiency of a weld in commercial steel plates welded with commercial steel wire may vary, a weld produced with commercially pure iron wire in commercially pure iron plate will consistently approach the characteristics of the plate (see Fig. 11) establishing the fact that chemical uniformity of the plate and wire should receive the most careful consideration. The welder is frequently handicapped by attempting to successfully weld (according to best established practice) a plate containing gases and other impurities.

Test of Good Welding Wire

As a general rule laboratory facilities are not always available to the consumer for testing welding wire. Besides, the preparation of test samples entails considerable time and expense. Therefore, it is necessary that a more or less rapid practical test be developed. The following method is offered in the hope that it will be of assistance to those interested and at the same time lead to further investigation and development. This test is made by laying the wire flat on a clean surface and applying a standard oxy-acetylene welding flame to it in such a manner as to heat it up for a distance of about six inches plying the flame back and forth until the wire is red and then slowly melting it, moving the flame so that the wire

Fig. 12
Indicating gases and slag contained in the wire.

Fig. 13

Fig. 14
Indicating absence of gases and slag.

Flame Test on Gas Welding Rods and Electrodes.

melts only half way through its diameter and thereby avoid picking up anything foreign to the wire itself. The smallest tip available should be used, care being taken to produce a neutral flame.

If the flame is withdrawn as soon as the metal begins to melt the impurities can readily be seen being thrown off in the form of sparks, or a boiling action will take place in the case of inferior material indicating undesirable elements such as gases and slag, and in some cases the metal will not flow together but tend to "run away." On cooling the metal will present a spongy appearance (Fig. 12 and 13). In the case of clean metal practically free from impurities, the wire will melt and flow together evenly without displaying any disturbing action (Fig. 14).

This test applies to both gas welding rods and electrodes. It does

not, however, indicate the actual welding characteristics of an electrode, but will give sufficient evidence of what may be expected in a weld deposit from such metal, notwithstanding the fact that the electrode may, in a good many instances, pass operating and other physical tests.

This melting test may also be conducted with electric welding apparatus by "freezing" the electrode to the work or plate regu-

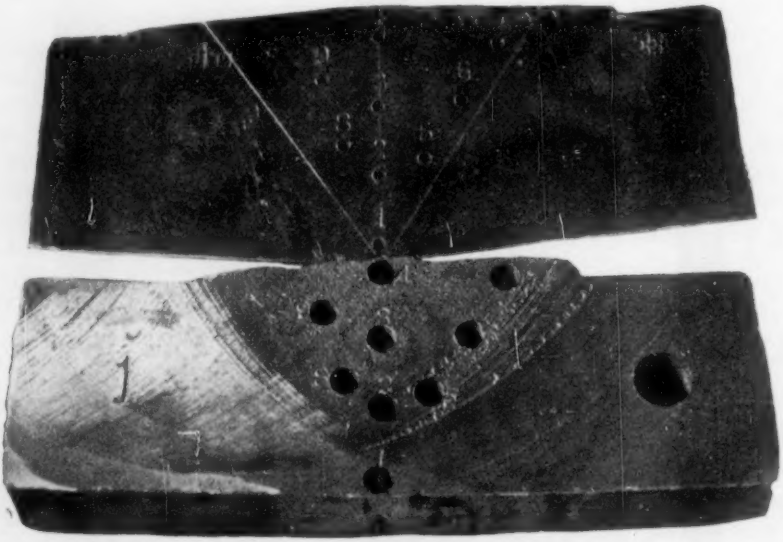

Fig. 15
Template for location of Chemical Analysis of Welds.

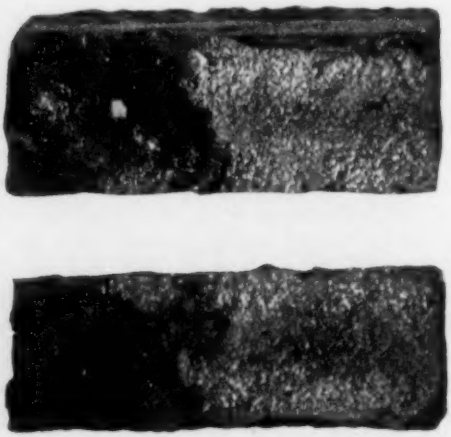

Fig. 16
Electric Weld.

Fig. 17
Gas Weld.

Figs. 16 and 17. Photographs of Broken Sections showing results obtained from Non-uniform Welding Material.

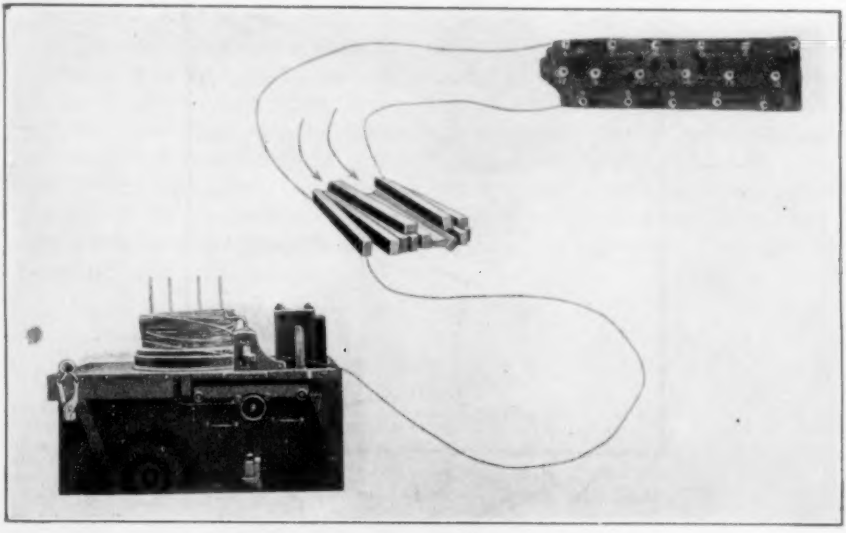

Fig. 18

Showing steps from the Ingot to Wire. Each Ingot weighs approximately 5,200 lbs., producing eight billets, each weighing approximately 650 lbs.—indicating the possible variation in billets from non-uniform ingots, therefore, variation in wire.

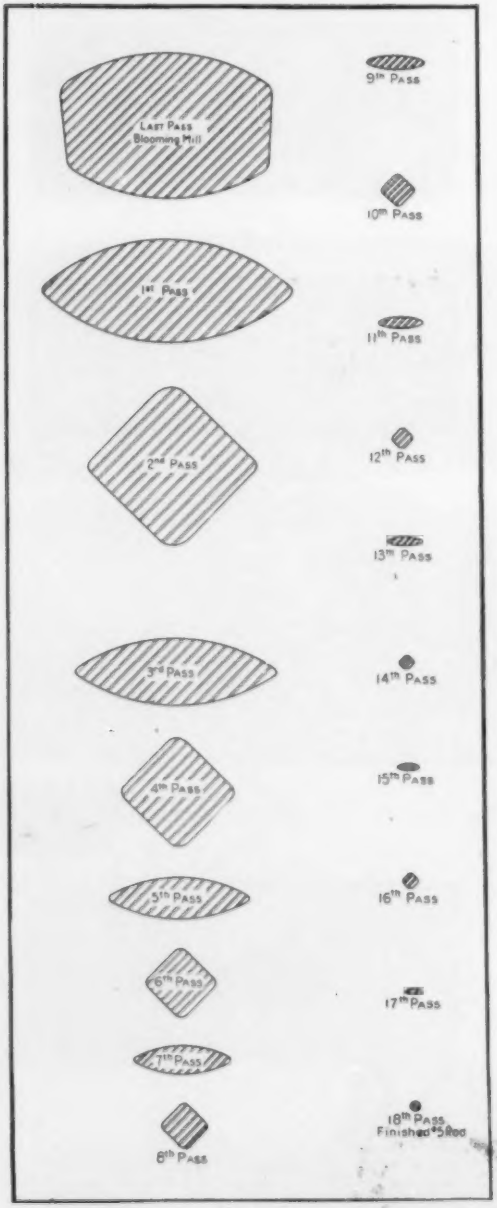

Fig. 19
Rod Mill Steps, showing reduction of 6" x 6" Billet to ¼" Rod.

lating the current to the size of the wire so that the wire heats up gradually and melts uniformly the full length of the wire. If the current is too high the wire will melt close to the plate only and

not present sufficient melted surface for observation. It is, therefore, necessary to adjust the current so that the wire slowly heats up and melts its entire length.

The tensile strength of a welding wire has been taken by some as an indication that a wire of a given tensile strength will produce a weld of equal strength. All available data proves conclusively that there is no relation between these figures.

Conclusions

Experience has shown that the success or failure of a weld depends on what might be termed the BIG 5 of welding, all of which are practically of equal importance, namely, the welder, which includes methods of welding, design of weld, welding equipment, metal to be welded and the welding wire. Metallurgy distinctly proves that certain elements are detrimental. Therefore, it is only logical to assume that dependable welding material should be as free as possible from these injurious elements.

Under the heading of what constitutes a good welding metal—although the last word may not be written for a considerable time—we would indeed be confident that if what might be termed the *BIG* 5 of welding wire were assured it would fulfill its obligations in the production of uniformly successful welds: A wire,

First—that produces a weld approaching the general physical characteristics of the base metal.

Second—that does not contain or tend to create gases.

Third—that is free from slag or slag forming ingredients.

Fourth—that is chemically and physically uniform.

Fifth—that embodies ease of operation.

Welding is an application of metallurgy and engineering and its study should be so approached. Any common baling or fence wire will no more meet the requirements of a dependable welding material than would metal of this analysis serve as tank plate or locomotive fire box steel. Science, sound judgment and common sense prevail in all materials of construction and in welding apparatus, and therefore must apply equally to welding material if we are to be consistent.

What Technical Foundation Should Foremen Welders Possess

By W. SPRARAGEN*

Inasmuch as a thorough treatise of this topic might easily comprise several volumes, I have endeavored to confine my remarks to only a few of the fundamental considerations.

General Analysis of Responsibilities and Requirements of Foremen

Industrial education has up to the present time been confined largely, if not entirely, along two lines, namely the training of executives and technical experts on one hand and skilled workers in the factory on the other. Very recently, however, considerable attention has been given to the training of minor executives, a group coming between the other two, and among which is included the foreman. Mr. J. C. Wright, Director, Federal Board of Vocational Education, has noted the fact that under present conditions there is a tendency to place increased responsibility on foremen and in a sense to expect more of them than they are at present equipped to furnish. In most cases this is due to the fact that foremen have been promoted from the ranks and have been changed from the work job to a foreman's job without any attempt ever being made to equip them for their new responsibilities. At the same time there has come about a greater recognition of the importance of the foreman as a key man.

The foreman job can be divided into three responsibilities, namely, supervisory, managerial and educational. Supervision by the foreman involves getting the job done and done correctly. Managerial responsibility must include the planning and utilization of ways and means to get the work done in the best possible way with the least amount of time, effort and expense. The third possible group of responsibilities of the foreman is in connection with the giving of some form of instruction. The scope and character of the instructional responsibility will be determined by the organization and the particular working conditions prevailing in the organization.

Upon further analysis of these conditions and responsibilities Mr. Wright states that the foreman should include the ability to deal intelligently with problems which come to him within the scope of his authority under the standard practice of the plant in which he is employed. Among the most important of these might be suggested the following: (1) An ability to handle cases involving the so-called human factor elements, or the industrial relations element, under the limitations of authority and procedure as stated above;

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(2) an ability to analyze a situation rapidly and the habit of so analyzing a situation before taking action; and (3) an ability to deal intelligently with situations involving costs where such situations fall within the foreman's authority, for according to the way he deals with them costs may be increased or decreased.

Requirements of Foreman Welders

It would be a relatively simple matter to analyze the best technical foundation suitable for any plant, shipyard, railroad, etc., but to attempt to define the foundation which would be suitable for the variety of conditions prevailing in different industries would be practically impossible. For instance, in a large production plant where the product is designed by the engineers and where the methods are not changed, Mr. S. W. Miller, one of the foremost engineers on gas welding states that less technical knowledge is needed than in a repair shop, where everything from a stove door to a stationary engine cylinder is worked on. In the former case, the responsibility of technical matter rests with the engineers and not with the foreman. In the latter case, the foreman should have as a minimum a high school education, the ability to read blue prints and an elementary knowledge of the principles of electricity, mechanics, strength of materials, boiler design, the characteristics of the ordinary metals and alloys, and a fair idea of the construction and operation of steam and gasoline engines. Knowledge needed for different shops would lie in between these two extremes.

Commenting along the same lines, Mr. H. Lemp, engineer of the Erie works of the General Electric Company, states that assuming the man picked out as a foreman already has the essential ability of handling men, his technical foundation should be along two lines, theoretical and practical. The theoretical training should include: (a) The three fundamentals of our grammar school, arithmetic, reading and writing correct English. (b) An elementary knowledge of physics (particularly elementary electricity and the laws governing compression of gases) chemistry and metallurgy. With an open mind and a willingness to improve himself he will naturally keep in touch with the general progress by reading and observation. The practical foundation should be that of a welder using electric arc welding, resistance welding and oxy-acetylene welding. If he has any practical knowledge of forge welding, all the better. If he is to be a foreman of general utility, he ought to know something about blacksmith work, foundry work, and boiler making, and general machine shop practice.

Analyzing the remarks made by a number of experts in the field I have come to the conclusion that a foreman welder should possess a knowledge of the fundamentals of welding, both gas and electric, should be able to manipulate an electrode or gas torch, and should have a thorough knowledge of the fundamentals of the fusion of metals, contraction and expansion, know something of the

physical properties of metals, strength of materials, testing methods, behavior of metals under static and dynamic stress, metallurgy, and chemistry and be himself an expert on the class of work which he is supervising. Moreover, Mr. O. H. Eschholz, of the Westinghouse Company, points out that as modern welding processes are still in their infancy and therefore continually undergoing development, it is particularly essential that the foreman welder be receptive to new ideas in the welding arts and that he increase his fund of knowledge at every opportunity.

Non-Destructive Methods of Examining Welds

By O. H. ESCHHOLZ*

As this subject is of great importance to the entire welding industry, it is desirable to periodically draw attention to any advances or achievements that may affect the development of commercial weld-testing means. The peculiar property of ferrous metals in permitting the passage of considerable current and magnetic flux, offers an excellent opportunity for the application of testing methods that distinguish variations in the distribution and intensity of such currents and fluxes. With the continued evolution of measurement technique, there is no doubt but that some practicable means will be eventually at the disposal of welding interests for determining the physical qualities of the more common welds by non-destructive methods.

In Vol. XIX of the 1919 proceedings of the American Society for Testing Materials, a record is given of an important series of investigations tending to correlate the magnetic and mechanical properties of steel. Mr. Burrows in concluding the discussion, stated that

(1) "The principle that there is a very close relationship between the mechanical and magnetic characteristics of steel is established on a firm basis."

(2) "Laboratory tests show that the commercial application of magnetic analysis to shop routine practice is practicable."

(3) "A magnetic examination of an object, such as a knife blade, or a ball bearing race, as it comes from the quenching bath will tell whether it is cracked or has been so badly strained in quenching that cracks are liable to develop under further thermal or mechanical handling."

(4) "The tests on rails clearly show that structural irregularity results in magnetic disturbances."

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(5) "Dudley has definitely located by magnetic means, a number of interior transverse fissures."

(6) "Gebert shows that a linear relation exists between his magnetic characteristic and the Brinell hardness and tensile strength."

Bulletin No. 343 of the Bureau of Standards discusses in detail the practical application of magnetic analysis to the detection of flaws in bar stock used in the manufacture of steel products.

On page 7 of the minutes of the Welding Research Sub-Committee of the Emergency Fleet Welding Committee is recorded the experimental results obtained when employing an electrical method of testing the efficiency of butt joints, devised by Mr. Conant. The results obtained indicated the possibility of utilizing the conductivity of a welded section as a criterion of weld strength. The writer had occasion some time ago to have a number of bars, $1\frac{1}{4}$ x $1\frac{1}{2}$ in. x 12 in., double scarfed to 45 deg., welded in series to serve as a preliminary test for the correlation of electrical conductivity and tensile strength. The following table compares the voltage drop across each weld on passing about 100 amperes, with the tensile strength:

U. T. S. per sq. in	Potential Drop	Voltage Difference
48,000	.294	0.000
32,400	.308	0.014
22,250	.314	0.020
10,780	.332	0.038
24,100	.317	0.023

It will be observed that even with this simple testing means, an increase of voltage across the weld signifies a decrease in weld strength. Further activity in the utilization of both magnetic and electrical test methods, has shown the possibility of detecting, in the laboratory, differences in weld strength of the order of 10,000 lbs. per square inch. The apparatus employed, while not commercial in its present form, could be made adaptable to numerous welded structures. As Mr. Burrows aptly states, "the man who denies the possibilities of magnetic (or electrical) analysis to-day, because of its not being a finished instrument of investigation would have rejected the aid of microscopic analysis or chemical analysis or any of the other means of testing in the early stages of these arts, which have since proved of so great service to man."

STANDARDIZATION RULES
FOR
ELECTRIC ARC WELDING APPARATUS

To the Welding Industry:

Several types of Arc Welding Apparatus are now being sold, but at the present time there is no agreement among the manufacturers of arc welding apparatus as to the basis of rating. A prospective purchaser is bewildered by the confusing claims that special merits pertain to the different machines on the market and unless he has had previous experience in welding, he has no sound basis for comparing the capacities of the several makes. We therefore believe that our Standards will be welcomed and sincerely hope that they will be of real service to the welding fraternity.

We realize, however, that the first issue of any such standards is likely to be imperfect, and hope that all of those interested will feel free to offer any criticisms or suggestions.

C. A. ADAMS,
Director, American Bureau of Welding.

REPORT TO THE AMERICAN BUREAU OF WELDING ON STANDARDS FOR ARC WELDING APPARATUS

We are submitting herewith Standards for Arc Welding Apparatus for use in connection with specifications for, and the purchase, sale and use of arc welding apparatus. Your Committee recognizes that it is the policy of the American Bureau of Welding, which is the research department on welding of the American Welding Society and the Division of Engineering, National Research Council, to prevent, insofar as possible, any conflict in standards issued by authoritative bodies relating to welding. In accordance with this policy and recognizing the Standards Committee of the American Institute of Electrical Engineers as the authoritative body controlling the standardization of electrical apparatus, we have transmitted these proposed Standards For Electric Arc Welding Apparatus to the Standards Committee of the A. I. E. E. with the request that that body shall study and in so far as desirable revise them at the earliest practicable date. The Standards Committee of the A. I. E. E. has responded to this request to the extent of submitting the material to a sub-committee under the chairmanship of Mr. F. M. Farmer. The present rules, in accordance with its regulations, have been approved by the American Bureau of Welding for a period of one year. It is hoped that by the end of that trial period these rules or a revision thereof will have been adopted by the Standards Committee of the A. I. E. E. If any modifications

are made by the A. I. E. E. Standards Committee, it will be desirable for the Bureau to subscribe to the A. I. E. E. Standards.

Wherever reference is made to A. I. E. E. Standards the numbers correspond to the 1921 edition of the Standards of the American Institute of Electrical Engineers.

Respectfully submitted.

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*W. Spraragen, Chairman, Sub-Committee, Standardization Electric Arc Welding Apparatus

*C. W. Bates	W. H. Namack
W. J. Beck	O. T. Nelson
*A. M. Candy	*P. O. Noble
*Alexander Churchward	M. J. O'Connell
S. Diggle	James W. Owens
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*C. J. Holslag	A. W. Slocum
E. S. Hurd	W. A. Turbayne
*O. A. Kenyon	R. E. Wagner
*J. C. Lincoln	H. I. Walsh
F. P. McKibben	E. Wanamaker
	*H. A. Winne

*Members of Sub-Committee on Standards for Arc Welding Apparatus.

STANDARDIZATION RULES FOR ELECTRIC ARC WELDING APPARATUS

1. Purpose and Plan of Rules

The purpose of these rules is to provide standards for use in connection with specifications for, and the purchase, sale and use of, arc welding apparatus.

2. Classification

For the purposes of convenient designation arc welding apparatus shall be considered to be of three general classes:

(a) *Generator or Motor Generator Class.* This class includes, special generators driven by prime movers, special generators direct connected to electric motors, converters and dynamotors.

(b) *Transformer Class.* This class refers to special transformers connected to a source of alternating power, the secondary circuit of which supplies the arc or arcs.

(c) *Rheostat or Reactor Class.* This class includes the type of equipment which is connected directly to the source of supply, the voltage being reduced by means of a rheostat or reactor to the proper value for the arc or arcs.

Definitions

3. *Arc e.m.f.* is the total e.m.f. between the electrode and base metal.

4. *Arc stream e.m.f.* is that portion of the arc e.m.f. that varies with the length of the arc.
5. *Electrode e.m.f.* is that portion of the arc e.m.f. that depends upon the character and condition of the electrode.
6. *Open circuit e.m.f.* of a welding circuit is the e.m.f. when no current is flowing.
7. *Time of recovery* is the time required to assume conditions to within 5 per cent of their final value in an automatically regulated welding circuit after a definitely specified disturbance has taken place. The time of recovery of a constant-current machine is measured as follows: Insert resistance in the welding circuit of such value that normal full-load terminal voltage of the machine is registered across it at full-load current; short-circuit one-half of the resistance and allow conditions to become stable; then instantly remove the short-circuit. The time required for the current to return to within 5 per cent of its original value is the time of recovery. The time of recovery of a constant-potential machine is measured as follows: Insert resistance in the welding circuit of such value that full-load current is registered at normal full-load voltage; short-circuit one-half of the resistance and allow conditions to become stable; then instantly remove the short-circuit. The time required for the voltage to return to within 5 per cent of its original value is the time of recovery.
8. *Closed-Circuit Arc System* is one in which the circuit is normally closed and the arcs are extinguished by paralleling them with a low-resistance circuit.
9. *Open Circuit Arc System* is one in which the circuit is normally open and the arcs are extinguished by separating the electrodes.
10. *Constant e.m.f.* welding source is one that automatically maintains its e.m.f. within 5 per cent of the full-load setting over the range from full-load to no-load and has a time of recovery of not more than 0.3 second.
11. *Constant Current* welding source is one that automatically maintains its current constant within 5 per cent of its rated capacity over the range of welding voltage, allowing from 15 to 25 volts per arc, and has a time recovery of not more than 0.3 second.
12. *Constant Power* welding source is one which, when adjusted to give rated power output with an arc voltage of 20, will automatically maintain this power output within 5 per cent of the rated value, with variations in arc voltage of 10 per cent above or below 20 volts, and has a time of recovery of not more than 0.3 second.
13. *Variable e.m.f.* welding source is one in which the e.m.f. reduces as the current increases, but not in such a way as to qualify as a constant-energy source.

14. *A Weld* is a solid union of metallic pieces formed by either heating to a fluid state the edges of the pieces to be joined and allowing the metals to flow together (with or without additional molten metal being supplied) without any pressure being supplied or by uniting or consolidating by hammering or compressing with or without previous softening by heat.
15. *Base metal* is the material in a weld which composes the pieces to be united by the weld. Unless otherwise expressly stated, it will be understood that a weld joins two pieces of identical material.
16. *Weld metal* is the material in a weld which has been used in forming the weld. It may consist entirely of the base metal adjacent to the weld or of the material added to the fused base metal from a welding rod or electrode or other material.
17. *Filling metal* is the metal added during the welding process to form part of the weld. In carbon-arc or gas welding it is supplied by means of a *welding rod*, in carbon arc by a *filling rod* and in metal arc welding by the *electrode*. (Note—In some cases in metallic arc welding it may be supplied by both *electrode and filling rod*.)
18. A *test weld* refers to a sample of welding which has been performed under known conditions and upon which tests are to be made.
19. A *test specimen* is a prepared piece from a test weld on which a test is to be made.

100. **Selection of Arc Welding Apparatus**

The following information relative to the apparatus which it is proposed to supply and the conditions under which it is expected to use such apparatus is to be furnished by the prospective supplier of the apparatus and the prospective purchaser respectively.

(*a*) *By Prospective Supplier*

1. Rating of apparatus, the rating to be defined as in A. I. E. E. Rule 3508.
2. Number of arcs that can be operated at one time.
3. For A.C. power supply (regardless whether welding apparatus is A.C. or D.C.) maximum momentary kilovolt-ampere demand, power consumption and power factor at normal rating. For D.C. supply maximum momentary power consumption and power consumption at normal rating.
4. Efficiency as defined in A. I. E. E., Rule 3514, and measured in accordance with Rule 102, given below.
5. Weight, dimensions and portability.
6. Maximum voltage variation permissible at the power supply terminals without causing unsatisfactory operation either momentarily or continuously.

7. Method of regulating current and the number of steps available.
8. Current and voltage characteristics of the apparatus.
9. List of accessories and attachments.

(*b*) *By Prospective Purchaser*

1. Kind of electric power available, i.e., D.C. or A.C.
2. If supply is A.C., give frequency and number of phases.
3. Voltage of supply circuit.
4. Normal fluctuation of voltage (and frequency if A. C.) of supply circuit at the point where the proposed apparatus is to be connected.
5. Regulation of circuit at point at which proposed apparatus is to be connected, that is, the drop in voltage per 100 k.w. line laod.
6. If no source of electrical power is available, give information in regard to the kind of mechanical power that is available for driving a special generator.
7. Apparatus to be portable or stationary.
8. Number of arcs required.
9. Supply of experienced welders.
10. General class of work to be welded.

Tests

101. *Temperature Rise.*—The temperature rise of any part of the apparatus after operating one hour at rated output shall not exceed the limits prescribed by the Standardization Rules of the A.I.E.E. for that class of apparatus when measured in accordance with those rules. The full rated output should be maintained continuously for one hour by means of a suitable resistance.

102. *Efficiency.*—(a) *Input-Output Method.* The efficiency shall be taken as the ratio of the power output to the power input after operating one hour continuously at the rated output with an ambient temperature not exceeding the limits prescribed by the A.I.E.E. for that class of insulation. Average of several readings taken at the end of the one hour run shall be used. The power output shall be measured at the machine terminals to which the arc circuits are connected and the power input shall be measured at the machine terminals which are connected to the source of supply.

(b) *Conventional Efficiency.* The conventional efficiency of an electric machine or apparatus is the ratio of the output to the sum of the output and the losses, or of the input minus the losses to the input, when, in either case conventional values are assigned to one or more of these losses. The conventional efficiency shall be measured as provided in the standardization rules of the A.I.E.E.

THERMIT WELDING

By J. H. DEPPELER*

Where an oxy-acetylene or an electric weld cannot be made all in one layer, the shrinkage of the second and subsequent layers is resisted by those already solidified and shrinkage strains may result.

Up to a certain thickness, strains will result in warping and the strains will thus be relieved; beyond this, the internal shrinkage strains will remain and early failure may result.

A thermit weld is made in one operation regardless of the thickness of the section.

Thermit welding is indicated in all heavy welding operations.

Many in the welding industry and many more outside of this industry do not realize the enormous strides that thermit welding has made and the great extent to which it is used in the industry. This is undoubtedly due to the fact that there are a great number of oxy-acetylene and of electric welds made for each thermit weld made, but since thermit welding is used principally on the heavier sections, the importance and the saving to the customer of this one thermit weld may very well be equal to the greater number of acetylene or of electric welds.

Most of you will be surprised to know that millions of pounds of thermit are used each year for important welding operations, that thermit welding is regularly used in over 95 per cent of the railroad shops of the country and that, in addition to the great number of thermit welding operations being carried on each day in ordinary repairs, our branches, shops and traveling operators are almost daily welding heavy parts, such as crankshafts over 12 in. diameter, heavy steamship stern frames (the sections of which are frequently greater than 12 in. square), etc. Thermit operations frequently require more than a ton of thermit per weld and occasionally fractures so enormous as to require three to four tons in one pour are negotiated.

Although the making of a thermit weld successfully does not in any way depend upon the manual dexterity of the operator, but rather upon the use of proper materials and the following of instructions carefully, nevertheless we who are interested in the promotion of thermit welding probably have almost as much difficulty maintaining the high average quality of the thermit weld as the promoters of oxy-acetylene and electric welding have in their case. This is due principally to the fact that the employer has come to know that he cannot be too careful in the selection of oxy-acetylene and electric welders, and that the strength and other physical qualities of the resulting weld depend almost entirely

*Chief Engineer, Metal and Thermit Corporation.

upon the operator so selected. He has, therefore, established training schools, given his operators every advantage of education and test practice, and where he and his operators are careful in the selection of work to be done with the acetylene torch or the electric arc obtained remarkably good results, but frequently this same employer, feeling that thermit welding is not so dependent upon the personal ability of the operator, is not so careful in the selection of these men. To him, also, there is no difference in the molding material recommended by us and the molding material which he has found successful in his steel, brass or aluminum foundry, so that you see, although the making of a good thermit weld does not depend greatly upon the operator, and although also of the many thousands of thermit welds made in the shops of this company or by its traveling representatives the number that have subsequently failed can be counted on the fingers of one hand, nevertheless we are continually striving for some way to get our customers to use equal care. In making this statement, we want you to know that it is really not an exaggeration and that it does not include those many failures wherein the weld has been unsuccessful due to the breaking down of the mold, entrapping sand in the thermit steel or perhaps allowing the thermit steel to escape from the mold, but does include all welds which have been made and passed as satisfactory at the time of welding.

In recent years a great deal has been done to improve thermit welding practice and the physical properties of the resulting welds. To those of you familiar with steel foundry practice, it may not seem an exaggeration to say that the thing of greatest importance in thermit welding is the selection of a proper molding material and that this molding material is necessarily very different than that ordinarily used in steel foundry practice. One can readily realize this when he considers that the pouring temperature of ordinary molten steel is only slightly over 2800 deg. Fahr., whereas the pouring temperature of thermit steel is over 5000 deg. Fahr. The securing of a molding material to withstand this temperature seemed at first an insurmountable problem because of the difficulty of securing this remarkable combination of refractoriness and porosity. The clays used with sand in the making of molding material in all cases fuse below 3000 deg. Fahr. and most of them below 2500 deg. Fahr. The high silica sands, however, withstand the temperature readily. Since it was evident that the main difficulty was the securing of a proper binder for this sand, we decided to select as a binder that plastic clay which was the most refractory and to use a minimum of this. To this end the sand and plastic clay are ground together in an attempt to coat each grain of sand with an infinitesimal thickness of clay. This has resulted in the development of a molding material which, when properly rammed into the mold so as to leave no loose pockets, will perfectly resist the extremely high temperature of thermit steel and yet at the

same time will be so porous as to hardly resist at all the escape of gases from the interior of the mold, always present in foundry work. The result is that where this new molding material is used and where thermit practice is followed, sound welds can be absolutely guaranteed and there is no longer any excuse for the occasional "honeycombed" weld.

Consider for a minute the remarkable physical properties that can be obtained in thermit welding. We should be careful not to confuse thermit steel with ordinary cast steel, because ordinary cast steel has resulted from the partial refinement of a rather impure pig iron; it contains many impurities other than those actually dissolved in the steel, and these impurities are thrown out to the grain boundaries as the metal solidifies. These cast steels, therefore, break at relatively low strains and these fractures follow these weakened grain boundaries. Thermit steel, on the other hand, is a "synthetic" steel, made by the reduction of pure iron oxide by the purest aluminum obtainable, and the result is naturally a steel of great purity. In fact, the only steel in industry which approaches it is that made in a prolonged electric furnace refining operation. As a result of this purity, the ordinary thermit sold for general use produces a steel having a tensile strength of 65,000 lb. to 70,000 lb. per square inch and an elongation of 20 per cent to 25 per cent on unworked and non-heat-treated samples. When this is used in the welding of ordinary steels, say, below .30 carbon, the specimens invariably break outside the welds, not along the line of fusion, or perhaps at some point just beyond where crystallization has taken place but really remote from the weld with a good, silky cupped fracture. And as to resistance to shock—say, listen—one of our largest steel companies in a recent test thermit welded a forged steel bar 9½ in. x 10 in. in section and then without heat treatment or annealing it, supported the bar on 4 ft. 6 in. centers with the weld at the middle and dropped a 3200-lb. ball on the weld—first from a height of a few feet and "drop by drop" increasing the height to 15 ft., when after nine drops at this height, the section had distorted and bent downward more than 2 in. It was then decided to turn the piece over to hasten the breaking; then, after a few more drops, the welded piece failed 4 in. outside the weld.

We are continually researching to improve thermit steels, and recently we have produced alloy steels with tensile strengths as high as 104,000 lb. per square inch. These so far are lacking in ductility, but many of those around 80,000 lb. have good ductility and resist shock and fatigue well.

Oxy-acetylene welding or electric welding, or both, are practical necessities in almost every factory and work-shop regardless of size, and for this reason they may always be better known generally than the thermit welding process, but for heavy digging operations the steam shovel is indispensable, and although men will

always try to use one of the other processes because they are so equipped, they will surely always find thermit indispensable for heavy welding operations. On heavy work, say, 1 in. or more in thickness, there is little or no difference in cost and the advantage of making the entire weld at one time and having but one shrinkage is evident. All three of the welding processes are important and, where really intelligently used, their fields hardly overlap.

To close this article without mentioning increasing popularity of the thermit rail weld by means of which thousands of rail joints are being eliminated almost every week and joint maintenance thus completely disposed of, and without mentioning the many installations of completely welded pipe lines, the thermit welding of which is simplicity itself, would not be presenting a true picture.

Every welder and everyone interested in welding should get to know the thermit welding process better.

CURRENT WELDING LITERATURE

TO OBTAIN COPIES OF PAPERS—The Engineering Societies Library is prepared to supply copies, translations, or abstracts of any papers in the Library at the following rates:

Translations, $5 per 1000 words and upward by arrangement.

Photoprint copies of articles, maps, etc., 25 cents per sheet (11 by 14 in.); typewritten copies, $1 per 1000 words.

Bibliographic searching, abstracting, etc., $2 per hour.

Communications should be addressed to: The Engineering Societies Library, 29 West Thirty-ninth Street, New York.

Autogeneous Welding. Railway Journal, Vol. 28 (June, 1922), pp. 17, 18. Report of Special Committee of Master Boiler Makers' Association. As a result of the inspection of welding in shops of 25 railroads, committee reports favorably as to the use of welding.

Autogeneous Welding of Copper. Autogene Schweissung von Kupfer, Acetylen (Jan., 1922), pp. 1-5, 2500 w.

Memorandum on Dangers from the Uses of Acetylene Gas and Oxy-Acetylene Welding in Factories. Official Bulletin issued by the Factory Department, Home Office, England. Describes the precautions to be used to avoid danger.

Daysohms "Utility" Arc Welder. Elec. Review, London (April 7, 1922), Vol. 90, pp. 498-9. A new field for electric welding describing the latest pattern of the Daysohms low pressure a.c. welder and its uses.

The Efficient Repair of Mining Plant and Machinery. C. W. Brett, Sci. & Art. of Mining (April 15, 1922), Vol. 32, pp. 297; Fdy. Tr. Jnl. (March 30, 1922), Vol. 25, pp. 228. Giving an example of what can be done in repairing a steam engine cylinder.

Electric and Magnetic Weld Testing as Applied to Butt-Welded Steel plates. Reprint paper to be delivered at the twenty-fifth Annual Convention of the A. S. T. M. T. Spooner and I. F. Kinnard. Paper describes a series of laboratory tests applied to arc butt-welded steel plates to determine the possibility of developing electrical and magnetic tests that will be capable of revealing the quality of such welds.

Erection of Steel Structures by Arc Welding. H. L. Unland. Proceedings of the Engineers' Society of Western Pennsylvania, Vol. 37, No. 9 (Dec., 1921), pp. 417-447. Application of arc welding to structural work, results of

tests on joints, speed and cost data, illustrations of different types of joints. Discussion of paper.

Expansion and Contraction. M. Piette. Acet. Jnl. (April, 1922), Vol. 23, pp. 515-8. Methods of overcoming distortion and failures when welding sheets, cylinders, pipes and tubes, sketches illustrating various points.

The History of the Development of Electric Welding. J. M. F. Wilson. Elec. News (April 1, 1922), Vol. 31, pp. 35-7, dealing particularly on the following: carbon electrodes, length of arc, the metal electrode, constants involved, the constant potential type machine, constant current type machine, selection of electrode, and impurities. Serial.

Oxy-Acetylene Process in Railway Shops. F. S. Tinder, Official Proceedings of the Car Foremen's Association of Chicago (March, 1922), Vol. 17, pp. 16-19-20, 23-4, 27-8, 31-2, 35-6, 39. Properties of Acetylene, Carbide and Oxygen. Development of oxy-acetylene process. Training of welders, supervision, preheating, preparation of weld, suggestions for the welder. Experience in welding on Virginia Railway. Discussion of paper.

Possibilities of the art of welding in Pipe Construction. F. K. Davis. Heat. & Vent. Mag. (April, 1922), Vol. 19, pp. 33-6. The remarkable adaptability of the welding and cutting torch to cut time and cost of this class of work. A number of prints showing welders at work on pipe lines.

Railroad Welding Standards, J. M. Calmbach, Acet. Jnl. (April, 1922), Vol. 23, pp. 496, 498, 500, 502, 504-6. General rules for using autogeneous welding, including boiler repairs and building up worn parts, with many illustrated repairs.

Repairing by Electro Thermit Welding. Reparaturschweissungen der Electro-Thermit Autog. Metallbearb. (March 15, 1922), Vol. 15, pp. 82-6—800 w.

The Success of Electric Welding. E. Wanamaker. Electrical Review and Industrial Engineer (April, 1922), Vol. 80, pp. 172-7. Careful preparation of work precedes welding; finished welds are inspected to determine the quality of the workmanship; welding equipment is purchased under specifications; coated electrodes are used for all welding; a few of the arc welding jobs done in the Rock Island shops.

Thermit Welding. Reactions. Vol. 15, No. 1. Rail Welding Simplified and Speed of Operations Greatly Accelerated; Eliminating Blow Holes in Thermit Welds by the Use of New Molding Material and New Style Mold Boxes; Reducing cost of Thermit Welding Locomotive Frames and other Sections; Different repair jobs.

Welding in the Oil Fields. Weld. Engr. (April, 1922), Vol. 7, pp. 34-35. Adoption of welded joints as standard for new pipe line construction. How gangs are organized for the work.

The American Welding Society

The American Welding Society is organized to provide united and co-operative action in extending the knowledge of the art of welding and its field of industrial application. The field for further application of welding is enormous, and progress in it is being delayed only by incomplete knowledge and by the confusing and opposing claims of competing interests.

The Society acts as a clearing house for information. Through papers and monthly meetings of local sections of the Society an opportunity is created for the individual manufacturer, engineer, plant superintendent, foreman, operator, etc., to contribute his own knowledge in welding and at the same time receive the benefit of the combined knowledge and experience of all other members of the Society. Special publications in addition to the regular monthly proceedings are issued from time to time giving results of researches, standardization work and other information of value to the members.

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Extracts From By-Laws

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Section 1. Individuals having received the approval of a majority of the Membership Committee shall become members of this Society upon the payment of dues, except in the case of honorary members who shall be elected by unanimous vote of the full Board of Directors.

Section 2. Membership shall be divided into five classes:

Class A. Sustaining members, being individuals or individuals delegated by corporations, firms, partnerships, etc., interested in the science and art of welding, with full rights of membership.

Annual dues $100.00

Class B. Members, being individuals interested in the science and art of welding, with full rights of membership.

Engineers or individuals competent by experience or training to plan or direct welding operations are eligible to this class.

Annual dues $20.00

Class C. Associate members with right to vote but *not* to hold office, except in Sections as may be provided for by the By-Laws of the Sections. Supervising welders, inspectors and skilled operators, with three or more years' practical experience in welding are also eligible to this class.

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Write to the Secretary for a membership blank.

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Starting with the July Issue this page will be reserved for advertisements of welding repair shops. Advertising rates for this space are shown below. Write to the Secretary of the Society for further information.

Space	Three Insertions	Six Insertions	Twelve Insertions
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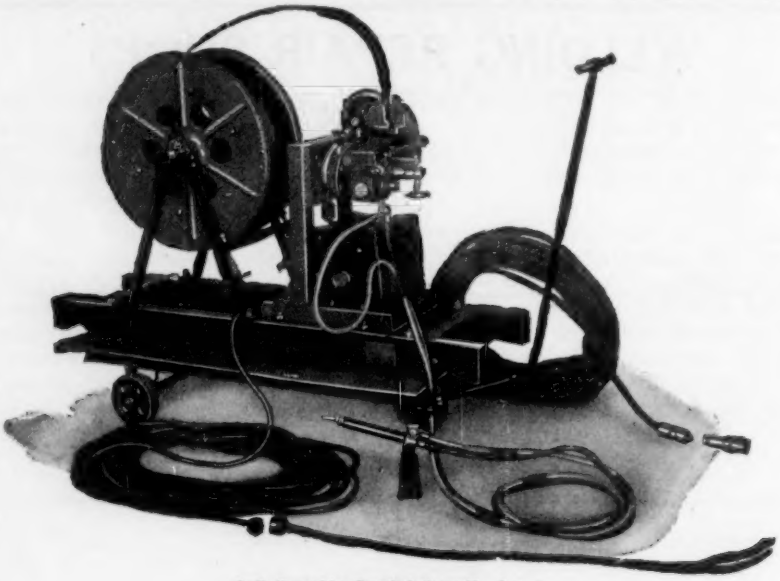

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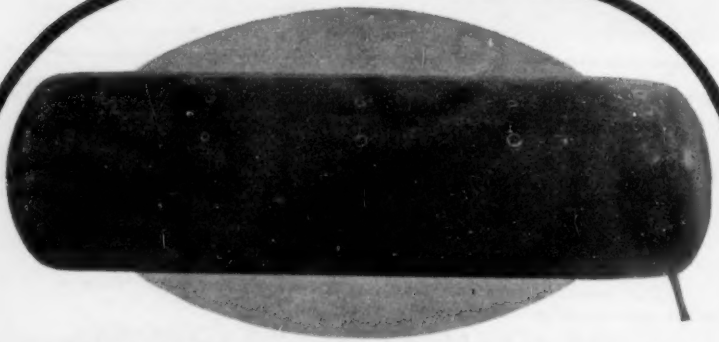

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